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MONTHLY PROGRESS REPORT NO. 12 FOR PERIOD 1 OCTOBER TO 30 OCTOBER 1964

Arthur D. Little, Inc.
Cambridge, Massachusetts

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National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio

THERMAL CONDUCTIVITY APPARATUS

During this month, we discontinued the testing program with the thermal conductivity apparatus and devoted our effort to writing the final report for this past year's work. Upon completion of our task with the equipment at the Lewis Research Laboratories, we recalled our field representative, Mr. Max Mellner, and turned over the operation of the apparatus located there to NASA personnel.

INSULATED TANK PROGRAM

During the month of October, we completed emissometer measurements of special shield materials and performed Test II-10, the last thermal performance test in the program.

Emissometer Studies

We performed emissometer measurements on several new and promising shield materials. These include gold coated Mylar, silver coated Mylar, and gold coating on aluminum coated Mylar. The emissivity results obtained are presented in Table I and in Figure 1. The data obtained with the gold coatings show a trend of increasing emissivity with increasing thickness as would be expected.

Test 221 performed with specimen coated with gold to a thickness of 2350°A gave an emissivity value of 0.20. This value compares with some of the best values reported for gold at or near room temperature. The data sample are too few to support firm conclusions at this time with regards to the smallest coating thickness that would correspond to the best surface emissivity. However, we suspect this apparent coating thickness for gold is about 2000°A.

Tests 222 and 223 were performed with specimens coated with silver on Mylar. Further, the silver on each film was protected with a light coating of silicone oxide. The average result obtained by us are comparable to those obtained with the gold specimen used in Test 221.

With regards to the measurement of the apparent thickness of the metal coatings, we have been using the resistance method of measurement. The sample size used in this measurement is 2 x 2 inches square. When the sample was sufficiently large, at least two resistance specimens were taken from the shield material in an area adjacent to that from which the emissometer specimen was taken.

Our Final Report will contain the results and discussion concerning the more than 160 measurements performed with the emissometer on a variety of specimens.

Calorimeter No. 1

Test II-10

In the first week of October, a purge bag was placed around the composite insulation system (System No. 5) and heat flux measurements were made with the calorimeter in a ground environment.

The purge bag was fabricated from a Mylar film-aluminum foil laminate. We estimate that the average distance between the bag and the foam substrate was 0.3 inches. The space between the foam and bag contained the five-shield multilayer system consisting of aluminized-Mylar and 8 mesh screen spacers.

A heat flux of 92.2 Btu/hr ft^2 was obtained with this system in Test II-10 as noted in Table II. The foam thermal conductivity could not be determined for the test as the surface thermocouples on the foam were inadvertently disconnected from the recorder at the time of test. However, by comparison with Test II-5[(1)], performed at Plum Brook Station, the heat leaks for the two are comparable. The differences between the two, i.e., 92.2 vs. 97 Btu/hr ft^2 can be explained in terms of the differential temperatures across the insulation and the fact that the II-10 test results are on a system with a helium layer formed with the purge bag. The principal temperature drop of the system occurs in the foam substrate. For example, with an ambient temperature of 72°F, we measured typical bag temperatures of about 22°F. The surface temperature of the foam substrate was not measured because the measuring points were inadvertently disconnected from the recorder. However, some temperatures measured on shield No. 3, which is displaced a small distance from the foam indicate temperatures of about 0°F. We estimate the foam temperature drop at about -320°F. On this basis, the estimated thermal conductivity is computed to be .0120 Btu ft/hr ft^2 $^\circ$F.

Test II-9B

In Test II-9B, we simulated vehicle configuration in which the propellant tank is shrouded with the vehicle air frame and the space between the two is purged with gaseous helium. The vacuum chamber baffle was used for simulating the shroud once the calorimeter was installed in the chamber. We obtained an experimental heat flux of 85.6 Btu/hr ft^2 as noted in Table II.

In this test, the baffles in the chamber were maintained at $66^{\circ}F$ through the use of circulated water. The only remaining thermocouple on shield No. 5 indicated an average temperature of $-3^{\circ}F$. The foam surface temperature was indicated to be about $-31^{\circ}F$ and of course the tank surface temperature was $-320^{\circ}F$. Thus, the temperature drop across the foam was typically about $289^{\circ}F$ which results in an experimental thermal conductivity of 0.0123 Btu/hr ft^2.

Test II-6D

Test II-6D is similar to test II-9B and was performed earlier in J-3 facility at the Plum Brook Station. There is a single noticeable difference between these tests in that the J-3 chamber baffles were not temperature controlled. The chamber wall served as the heat source. Under these conditions, we obtained a heat flux of 69.1 Btu/hr ft^2.

In this test, all the foam surface and outer shield temperatures were available. The data show that both of these surfaces are warmer at the top of the tank and get progressively cooler in the direction of the tank bottom. These gradients and how they vary with time during the progress of the test can be seen in Figure 2. We ascribe this time dependent on the fact that the cooling water was not used in the chamber baffles and jacket and the entire system including the chamber was cooling with time. From the computed heat fluxes and average foam surface temperature, the computed thermal conductivity is .0110 Btu/hr ft^2.

TABLE I

Summary - Emissometer Data

ADL Emissometer Test No.	Sample Description	Coating Thickness(°A)	Coating Emissivity (1)(2)
202	Gold-vapor deposited on 1 mil Mylar	1.5	0.247
203	Same as 202	29.3	0.0769
207	Same as 202	< 1	0.857
208	Same as 202	2.9	0.356
210	Gold-vapor deposited on aluminum that is vapor deposited on ½ mil Mylar	500 (3)	0.0254
211	Same as 210	411 (3)	0.0235
212	Same as 202	29.7	0.0722
224	Same as 202	135	0.0443
226	Same as 202	52	0.0633
214	Gold-vapor deposited on .15 mil Mylar	78	0.0485
215	Same as 214	147	0.0287
220	Same as 214	224	0.0302
221	Same as 214	2350	0.020
222	Silver-vapor deposited on Mylar, protected with thin silicone oxide coating	2810	0.0227
223	Same 222	2000	0.0175

(1) Sample emissivity at 93°F

(2) Receiver Disc No. 3 coated with platinum black on 2 mil gold was used to obtain measurements.

(3) Aluminum coating thickness is approximately 300°A

TABLE NO. II

Tank Insulation Program

Test Summary, Insulation System No. 5, Calorimeter No. 1

Insulation System: Composite insulation system consisting of ½ inch thickness of foam substrate and five shields of Mylar film aluminized on both sides. Shields are separated with 8 mesh vinyl coated Fiberglas screen.

Test Facility: A. D. Little, Inc., Cambridge and NASA/Plum Brook Station, J-3 facility as noted.

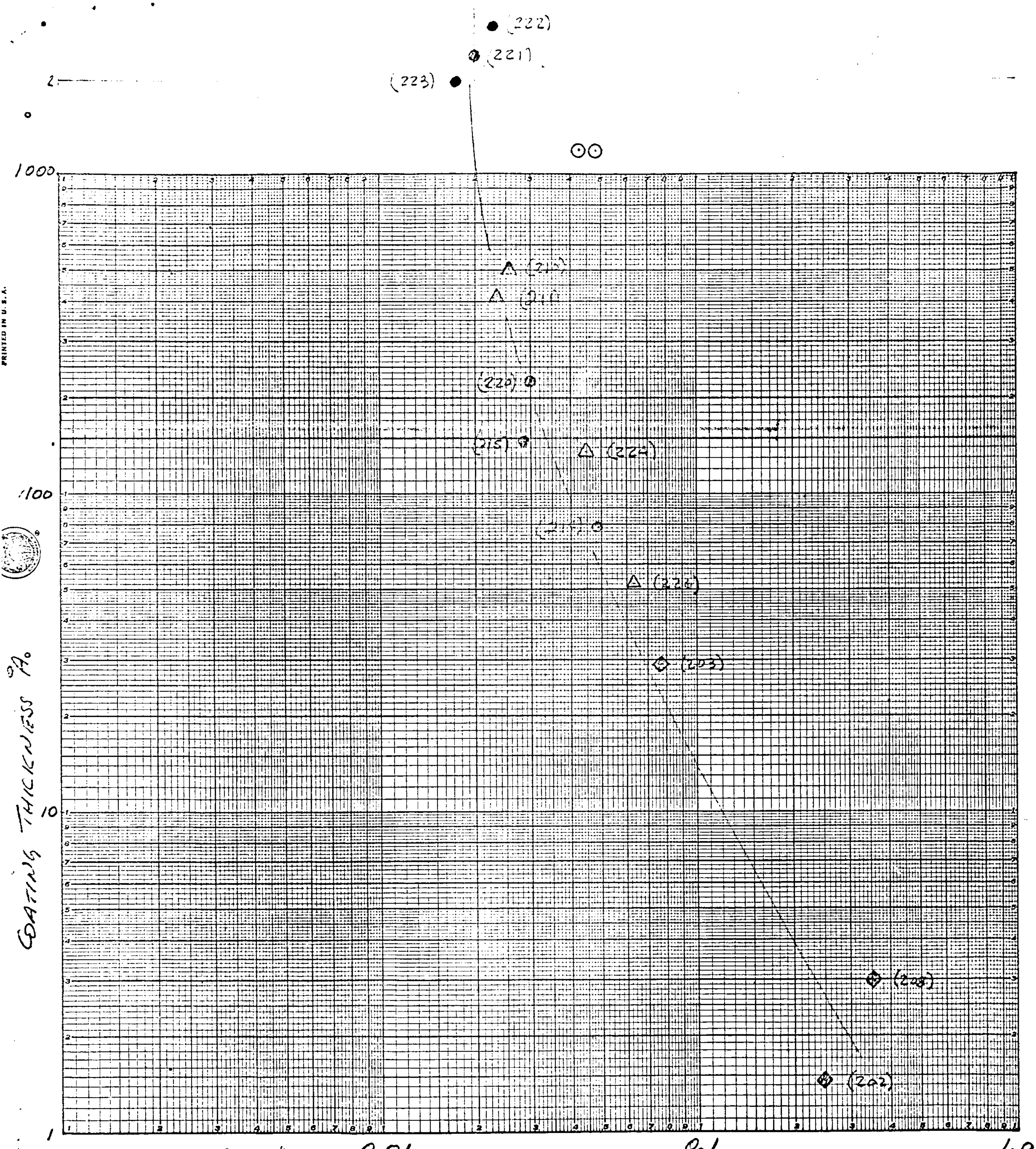
Penetrations or Gaps: None

Boundary Conditions: Calorimeter filled with liquid nitrogen is placed in natural ground environment.

Tank Surface Aera: 39.8 ft^2

Test No.	Tank Liquid	Data Period Date&Time	to Date&Time	Test Duration (hrs)	Ave. Vac. (mm Hg)	Guard Liq/Temp (°F)	Total Heat Flow (Btu/hr)	Measured Heat Flux (Btu/hr ft^2)	Ave. Warm Boundary Temp. (°F)
II-10 (1)	LN_2	10/7/1420	10/7/2200	8.16	--	--	3670	92.2	72
II-9B (2)	LN_2	9/23/1030	9/23/2330	13.0	--	--	3400	85.6	66
II-6D	LN_2	9/14/1400	9/15/0800	18.0	--	--	2750	69.1	30

Notes:
(1) Insulation system surrounded with bag, purged with helium. Test performed in ground environment at A. D. Little, Inc. facilities.
(2) Insulation system without bag in A. D. Little, Inc. Chamber. Chamber purged with helium at 1 atmosphere.
(3) Insulation system without bag in NASA/Plum Brook facility. Chamber purged with helium at 1 atmosphere.



EMISSIVITY

Δ NRC - large sheet -

● SiO_2 ON SILVER ON MYLAR, SCHJELDAHL 647, 648

⊗ SCHJELDAHL 642-645

◈ NRC (THIN GOLD COATINGS)

Δ NRC - GOLD OVER AL. ON MYLAR.

EMISSIVITY VS ~~GOLD~~ SILVER COATING THICKNESS ON MYLAR

FIGURE 1

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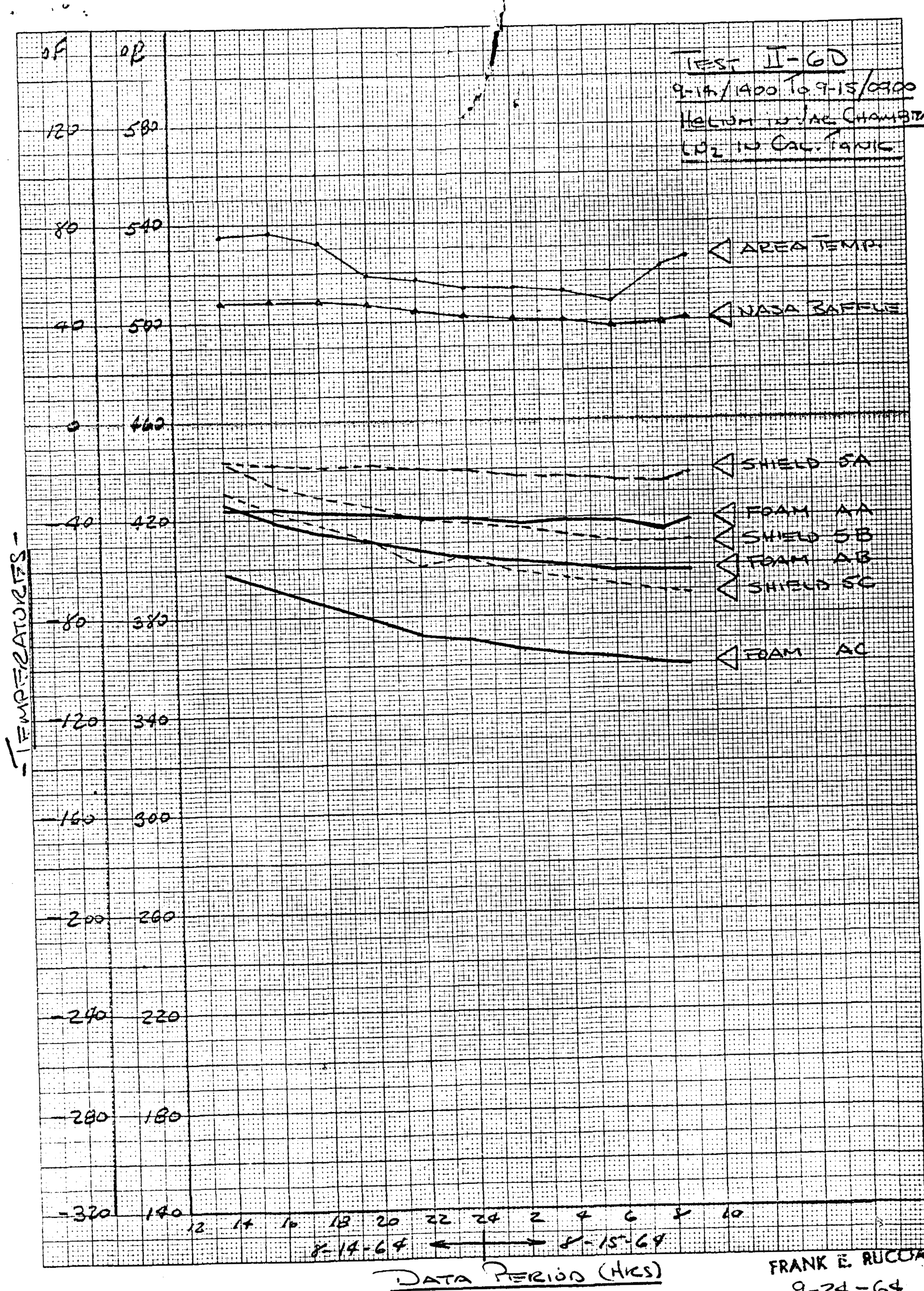

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FIGURE 7